

Research Proposal for the use of Neutron Science Facilities

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20111557
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S1578
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03/14/11

☐ Fast Access ☐ Joint CINT Proposal

Program Advisory Subcommittee: Basic Nuclear/Particle Physics			
Focus Area:			
Flight Path/Instrument: 1FP05-A / ER1		Dates Desired:	
Estimated Beam Time (days): 21		Impossible Dates:	
Days Recommended: 0			
TITLE Investigation of fission gamma-rays for isolated resonances of ²³⁹ Pu in the epithermal neutron energy range		<input type="checkbox"/> Continuation of Proposal #: <input type="checkbox"/> Ph.D Thesis for:	
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RESEARCH AREA		FUNDING AGENCY	
<input type="checkbox"/> Biological and Life Science <input type="checkbox"/> Chemistry <input type="checkbox"/> National Security <input type="checkbox"/> Earth Sciences <input type="checkbox"/> Engineering <input type="checkbox"/> Environmental Sciences <input checked="" type="checkbox"/> Nuc. Physics/chemistry <input type="checkbox"/> Astrophysics <input type="checkbox"/> Few Body Physics <input type="checkbox"/> Fund. Physics <input type="checkbox"/> Elec. Device Testing <input type="checkbox"/> Dosimetry/Med/Bio <input type="checkbox"/> Earth/Space Sciences <input type="checkbox"/> Materials Properties/Test <input type="checkbox"/> Other:		<input type="checkbox"/> Mat'l Science (incl Cond Matter) <input type="checkbox"/> Medical Applications <input type="checkbox"/> Nuclear Physics <input type="checkbox"/> Polymers <input type="checkbox"/> Physics (Excl Condensed Matter) <input type="checkbox"/> Instrument Development <input type="checkbox"/> Neutron Physics <input checked="" type="checkbox"/> Fission <input type="checkbox"/> Reactions <input type="checkbox"/> Spectroscopy <input type="checkbox"/> Nuc. Accel. Reactor Eng. <input type="checkbox"/> Def. Science/Weapons Physics <input type="checkbox"/> Radiography <input type="checkbox"/> Threat Reduction/Homeland Sec. <input type="checkbox"/> Other:	
		<input type="checkbox"/> DOE/BES <input type="checkbox"/> DOE/OBER <input type="checkbox"/> DOE/NNSA <input checked="" type="checkbox"/> DOE/NE <input type="checkbox"/> DOE/SC <input type="checkbox"/> DOE/Other <input type="checkbox"/> DOD <input type="checkbox"/> NSF <input type="checkbox"/> Industry <input type="checkbox"/> NASA <input type="checkbox"/> NIH <input type="checkbox"/> Foreign: <input type="checkbox"/> Other US Gov't: <input type="checkbox"/> Other:	

PUBLICATIONS**Publications:**

4FP90L:

Trans.Amer.Nucl.Soc. 102(2010)490

Trans.Amer.Nucl.Soc. 102(2010)151

Bulletin of the Amer.Phys.Soc. 55, No.14(2010)102

Abstract: S1578_Pu_n,gf.pdf

By electronic submission, the Principal Investigator certifies that this information is correct to the best of their knowledge.

Safety and Feasibility Review(*to be completed by LANSCE Instrument Scientist/Responsible*)

- ☐ No further safety review required ☐ To be reviewed by Experiment Safety Committee
☐ Approved by Experiment Safety Committee, Date:

Recommended # of days:**Change PAC Subcommittee and/or
Focus Area to:****Change Instrument to:****Comments for PAC to consider:****Instrument scientist signature:****Date:**

Investigation of fission gamma-rays for isolated resonances of ^{239}Pu in the epithermal neutron energy range

Summary

New measurement of fission gamma-rays for isolated resonances of ^{239}Pu is needed to support the LANSCE fission investigation program. Gamma-ray spectra will be investigated using fission ionization chamber and BaF_2 gamma-detector at neutron energies below 100 eV.

Background

Nuclear fission reaction is a subject of detailed investigation at LANSCE under support of the Fuel Cycle Research and Development (FCR&D) program. The two-step reaction – gamma-ray emission with following fission – is useful tool for nuclear fission quest. Information obtained from $(n, \gamma f)$ -reaction study can be used for many applications spanning from cross sections evaluations of neutron-induced reaction for fissile nuclei to a fission theory development. For example, it was shown [1] that contribution of the $(n, \gamma f)$ -reaction to the total fission cross section of ^{239}Pu at neutron energy of 1 keV is about 10% whereas the results of neutron capture cross section calculation at neutron energy of 1 MeV with and without of the $(n, \gamma f)$ -reaction contribution differ by almost a factor 2. From other side a search of gamma-ray spectra from the $(n, \gamma f)$ -reaction can give information about a structure of fission barrier.

In the past gamma-ray spectra from the $(n, \gamma f)$ -reaction were investigated for ^{239}Pu [2]. In [2] a spectra shapes measured from some weak ($\Gamma_f < 10$ meV) and strong ($\Gamma_f > 10$ meV) 1^+ -resonances were compared. Fig. 1 presents obtained ratio of fission gamma-rays spectra. It was confidently discovered that gamma-ray spectrum from weak resonances is significantly harder than that for strong resonances. That could be interpreted as a contribution of transitions to vibrational states in the second well of the ^{240}Pu fission barrier at excitation energies 1-3 MeV below the neutron binding energy [1].

The difference pulse-height gamma-ray spectra for weak and strong 1^+ -resonances of ^{239}Pu gave an estimation of pre-fission gamma-ray spectrum [3]. That difference is presented in Fig. 2. That result is in a reasonable agreement with other measurement [4]. Both [3] and [4] results show possible structures in the pre-fission gamma-ray spectrum but accuracy of those results is not enough to make a confident conclusion.

To get reliable data for pre-fission gamma-ray spectrum for the $(n, \gamma f)$ -reaction, a new measurement is required. The preferred way to make this measurement is using the same technique of a comparison of spectra measured for weak and strong resonances of ^{239}Pu at the energy range below 100 eV. This experiment will use advantage of high neutron flux of the LANSCE moderated neutron source and available short flight path, about 8 meters to maximize counting rate. Obtained information can be useful for understanding of the structure of highly excited states in heavy nuclei, both in 1-st and 2-nd wells of the fission barrier, and radiative transitions between them.

Proposed experiment

Measurement should be done using existing parallel plated fission ionization chamber loaded with a ^{239}Pu deposited foil are available at the LANSCE-NS group. The DANCE type BaF_2 scintillator crystal should be used as a gamma-ray detector. DAQ system will be based on a 2 ns waveform digitizer. Digital processing of accumulated waveforms can provide timing resolution better than 1 ns, which is important for that measurement. The main parameters to be accumulated are incoming neutron time-of-flight, secondary time-of-flight triggered from the fission chamber and stopped by a signal from gamma-detector, and a gamma-ray pulse height. Proposed beam line is 1FP5 at LANSCE.

Beam request

We request 21 days at the Flight Path 5 of the Lujan Center for statistic accumulation.

List of participants

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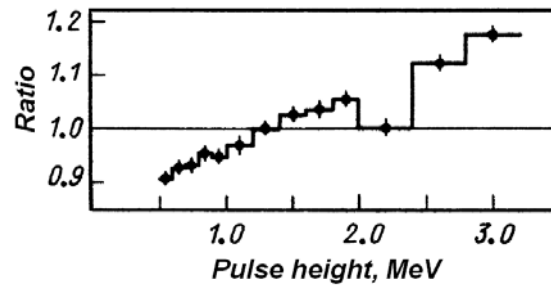


Fig. 1. Ratio of fission gamma-ray spectra measured for weak and strong 1^+ -resonances of ^{239}Pu [2].

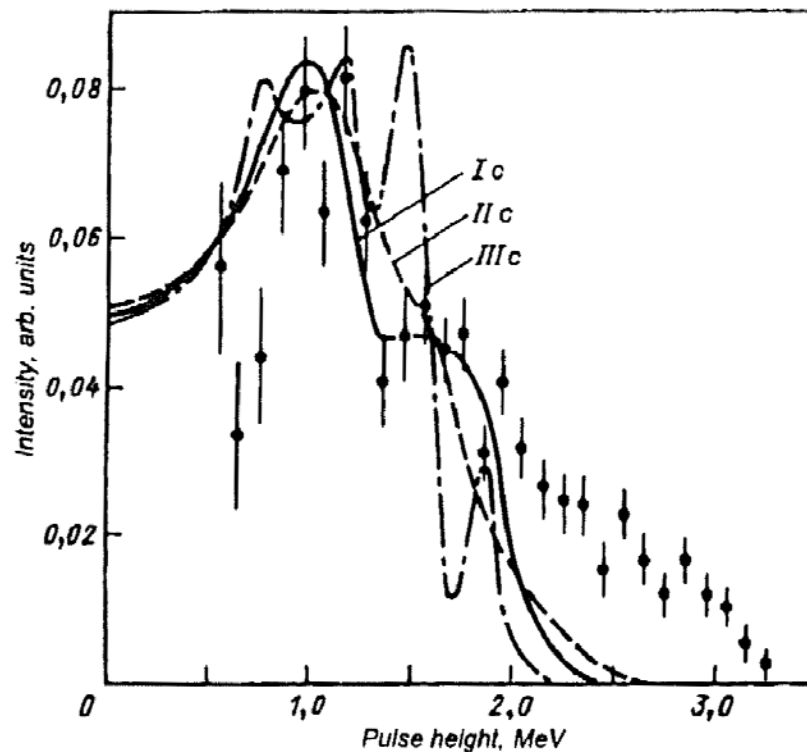


Fig. 2. The difference pulse-height gamma-rays spectra for weak and strong 1^+ -resonances of ^{239}Pu [3]. Also there are some spectrum calculations in the plot.

References

1. O.A. Shcherbakov, *Sov. J. Part. Nucl.* **21**, #2 (1990) 177.
2. G.Z. Borukhovich, T.K. Zvezdkina, A.B. Laptev et al., Neutron Physics. Proc. of the 6th All-Union Conference on Neutron Physics, October 2-6, 1983, Kiev. Institute of Atomic Information, Moscow, 1984, Part I, p. 304.
3. O.A. Shcherbakov, A.B. Laptev, A.S. Vorobyev, Astrophysics, Symmetries, and Applied Physics at Spallation Neutron Sources. World Scientific, New Jersey, 2002, p. 123.
4. J. Trochon, Physics and Chemistry of Fission. Proc. of an Intern. Symposium on Physics and Chemistry of Fission, Jülich, 14-18 MAY 1979. IAEA, Vienna, 1980, Vol. I, p. 87.